THE SOUTHERN BÜKK (N HUNGARY) TRIASSIC REVISITED: THE BERVAVÖLGY LIMESTONE

by

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Abstract

The Bervavölgy Limestone lies north of Eger, in the Southern Bükk Mts. (N Hungary). Its stratigraphic position is unclear; tectonic contacts with Jurassic (?) silty shale and Middle – Upper Triassic (?) cherty limestone were observed. No previous facies investigations have been made on this formation. Its age was determined as Ladinian (Schréter), Middle Carnian, later as Uppermost Carnian – Norian (Balogh).

The recent investigations recognized a Ladinian, Wetterstein-type reef complex, with open lagoon, plateau margin sand dunes and reef. Its flora and fauna (algae, calcareous sponges and foraminifers) are similar to those of the Wetterstein limestone. Up to now only the Ladinian age is proven. The rock texture indicates significant pressure after diagenesis, below the anchimetamorphic grade.

Up to now the Wetterstein limestone was known in a small, Hungarian part of the Silice nappe. This locality is the southernmost occurrence of Wetterstein-type limestone in the Inner West Carpathians.

Introduction

The aim of our work was to study the microfacies one of the limestone complexes of the Bükk Mts., Norththern Hungary, Inner West Carpathians. We have investigated two quarries at Felnémet and at Felsőtárkány between Berva Valley and Mészvölgy Valley and the limestone sequence of borehole F – 8. Some outcrops between the localities have been examined also.

The investigation of the Bervavölgy Limestone was the diplom thesis work for F. VELLEDITS in 1984 and 1985, following the suggestions of P. PELIKÁN. CS. PÉRÓ joined the field work in December, 1984. The study of the literature on carbonate microfacies, the preparation of thin sections, their description, interpretation and the facies analysis was made by F. VELLEDITS.

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2. Historical background

The first detailed geological survey and description of the area examined was made by Schréter (1912, 1935, 1943a, 1943b). Based on fossils (gastropods) he compared the limestone to the South Alpine carbonate facies (Esino, Marmolata). It was correlated with the Cassian beds (by corals, crinoid stems and Cidaris spines).

Márton (1957) was the only one, who stressed the differences between the rocks in Berva and Mészvölgy Valley. Balogh (1964) in his monograph on the Bükk Mts. considered the Berva Limestone as a heteropic facies of the Fennsík Limestone, being of Carnian age based on faunistic data. In his review on the correlation of the Hungarian Triassic formations (1981), he ranged it into the Uppermost Carnian – Norian.

No detailed, modern facies investigation was made on this area before our study.

3. Stratigraphic and tectonic position

Several different lithologies are found in the investigated region. Following the sequence north-westward from the Bervavölgy Limestone locality the following complexes come one after the other forming 200 – 450 m wide bands:

– Silty shale – shale (Jurassic?), contacting the Bervavölgy Limestone along fault of 65 – 70° dip;

– Cherty, platy limestone (Middle-Upper Triassic?). There is direct contact with the Bervavölgy Limestone on Tűzkövesorom Hill;

– Sandstone, shale with gabbroic intrusions and diabase pillow lavas (Jurassic to Cretaceous?) at Szarvaskő.

Several localities have been found, where different lithologies have tectonic contacts along deeply dipping faults. Towards the south and east the Bervavölgy Limestone is covered by Tertiary basin-filling sediments.

Tectonic position of the Bervavölgy Limestone:

– According to the opinion of Schréter (1943b) it forms tectonic windows below a scale made of shale-siltstone.

– Balogh (1964) supposed a continuous sequence between the lower, Lower Ladinian shale and the upper, Upper Ladinian – Carnian limestone.

– Kovács (1985, pers. comm.): The Bervavölgy Limestone might be the remnant of a nappe overthrust over the shale, or an olistothrymma within it.

4. The Felnémet limestone quarry

4.1. Sequence

The quarry is situated in the SW flank of Berva-bérc Hill, at an altitude between 360 and 508 m a.s.l. The rocks are exposed on five floors. The 600 m long quarry walls expose a 350 m thick sequence only, due to the 315/35° dip of the strata. The rock is crossed by several systems of faults, (Plate I. fig. 2.) providing way for intense solution by thermal waters and carbonate mineralization. Due to compressive stresses the original texture shows considerable deformation. The quarry scree covers the walls up to great heights.

A general description of the sequence will follow, and the characterization of some interesting profiles.

The I. group of beds is underlain by a few metres thick, bedded, medium to light grey limestone. It is covered by 85 m white, homogeneous limestone. Rare light grey beds contain frequent synsedimentary fissure infills; these may indicate occasional subaerial exposure. Fossils were observed on weathered surfaces: crinoids, echinoid fragments, mollusc shell fragments, coral debris, gastropods, sphinctozoans and brachiopods. An autochthonous coral colony was observed also. This group have been deposited in a well oxygenated, subtidal environment near a reef.

The II., dark grey group of beds is developed from the white limestone by alternating white and grey beds of 20 – 30 cm thickness, formed of coral debris, or it has been deposited on the uneven surface and in small fissures of the white limestone (Plate I, fig. 1). The appearance of light to dark grey, well-bedded rocks indicate a sudden change in the depositional environment. The sedimentation was continued in a shallower, often restricted lagoonal environment far from the reef. The variability within the basin is well shown by the fact, that the continuous and discontinuous transition between the two environments was obserbved within a distance of 35 metres.

The dark grey limestone is 30 m thick, with alternating 2 – 4 m thick dark grey strata with intraclasts and thinner (1 – 1,5 m), homogeneous beds. Bedding surfaces are frequently stilolitic with thin clay films. Wedges of coarse-grained beds with black brecciated clasts were frequently observed.

The III. group of beds forms more than half of the exposure, being ca. 200 m thick. It shows a gradual transition to the dark grey underlying sediments. Cyclic interfingering of 1 – 3 m thick, light grey and 0,1 – 1 m thick dark grey limestone beds can be observed, with gradual transition (Plate II, fig. 1). The light, homogenous limestone turns into a plastoclastic limestone upwards, made of mixed light and medium grey lime mud. In the upper part of both types an enrichment of black and grey intraclasts of 1 – 5 cm diameter were observed. This is covered by dark grey, partly dolomitic limestone. Two kinds of dolomitization can be obesrved: redeposition of yellowish brown dolomite mud to form 5 – 10 cm lenses or a homogeneous dolomitization during early diagenesis. A yellowish white, microlaminated, fenestral algal mat layer terminates the cycle, with frequently fractured upper parts. There is no terrigenous material on the resorbed surfaces, not counting clay films less than 1 mm in thickness.

The IIIrd group of strata is divided by a white limestone bed (Plate II, fig. 2). This level overlies the resorbed surface of the dark grey limestone (Plate II, fig. 3) or interfingers with it. It is somewhat similar to the white limestone of the Ist group of strata with homogeneous matrix. It contains rounded, white intraclasts, mollusc and echinoderm fragments up to 3 mm in diameter.

It is again overlain by cyclic sediments with somewhat thicker light grey beds with less black intraclasts. The dark grey beds are thinner and the beds with coarse black breccia are of subordinate importance (Plate II, fig. 2). The higher part of the IIIrd group of beds is characterized by darker cycles again; it frequently shows spotty dolomitization.

The IVth group of beds is almost 50 m thick. Large boulders with resedimented coral colonies and coarse (10–30 cm) synsedimentary breccia were found in the scree. This facies indicates a sudden change in the sedimentation environment. The sequence of the quarry wall is characterized by cyclic alternation of medium and dark grey limestone beds. Two white limestone beds within the group overlay intraclastic grey limestone with black breccia and frequent dolomitic lenses. The lower, 2,5 to 3 m thick white bed is fine grained limestone with echinoderm fragments. The upper, 9 m thick white limestone bed locally contains abundant coral fragments. The scree of the wall yielded ammonites related to *Ptychites* (Plate VIII, fig. 1–2) and the cross-section of a *Megalodon* (?), 10 cm in diameter. (Plate VIII, fig 4). The sequence of the quarry is closed by a medium grey, homogeneous and a medium to dark grey microlaminated limestone (Profile Fn–IV).

4.2. *Facies types in the Felnémet limestone quarry*

Seven main facies types have been distinguished by field observations and laboratory examinations.

Facies I: Algal mat bindstone

Macroscopic description: Alternating, 2–8 mm thick yellowish white and 02,–4 mm thick greyish, parallel laminae. The dark laminae are rarely substituted by 1×3 mm holes in rows, filled by sparite (fenestral structure). Locally fragmented due to desiccation (Plate III, figs. 1–2).

Microscopic description: The thicker, white laminae are built of micritic substance, secreted or bound by bluish-green algae; locally dolomitized. The darker laminae or lenticles are made of calcite spar. Desiccation cracks are filled by coarse grained calcite. The void-filling calcite crystals display a 45° orientation due to tectonic stress.

Interpretation: Intertidal algal mat facies (e.g. Fn–II, 11,5–12,5 m; 16,9–17,0 m and Fn–III: 5,0–5,25 m; 7,56–7,66 m).

Facies II: Oncoid grainstone/rudstone

Three groups were separated within this facies according to the material of the dominant oncoids and to the quality of encrustations.

Macroscopic description: Oncoids and encrusted algal fragments in medium grey matrix. There are 2 – 3 cm thick oncoid layers, with upwards fining grain size (from 8 to 2 mm) (Plate V, fig. 1). Elongation of intraclasts makes an angle of 40 – 45° with the bedding. (Plate VI, fig. 2). Microscopic description: Encrusted grains (4 – 8 mm), among others black, rounded, medium grey mud clasts up to 2 mm in diameter. Mostly algae (Solenoporaceae, Codiaceae) form the cores of the larger coated grains (Plate V, fig. 2, 4). Twenty percent of oncoid cores are formed of micritic mud clasts (never deformed) and recrystallized biogenic fragments. The coating of the grains is intact, regular, showing 2 – 3 layers. Uncoated biogenic fragments also occur in the matrix in subordinate quantities: foraminifers and crinoid plates corroded by algal activity. Interpretation: Wave action constantly kept the grains in motion, making them rounded and coated. The sediment was deposited in an intertidal environment under wave action.

Facies II/a: The oncoids are dolomitic or calcitic; there are multiple oncoids among the formers (Plate VI, fig. 1 – 2).

Interpretation: The occurrence of oncoids indicate a shallow marine, rarely hypersaline environment. If the sediment spent more time under strong wave action, multiple oncoids were formed (e.g. Fn – III: 7,28 – 7,38 m; 10,82 – 11,00 m).

Facies II/b: There are vadose pisoids besides the oncoids. Also stylolitic surfaces occur every 2 – 3 cm, with partly solved clasts.

Interpretation: Components of different origin are mixed here:

1. Grains coated by algae and bacteria were formed in a permanently moving water, in the zone of intense wave action.

2. Vadose pisoids were formed above the intertidal zone, and were resedimented to wave-affected zones. Long, arid periods with hypersaline periods alternated with short periods, when diluting effect of fresh water (meteoric water) is dominant. The unsaturated water solved sediment particles, then the exsolved carbonate precipitated in the deeper part of the vadose zone. This is the explanation for the formation of pisoidic crusts parallel with the bedding (Plate V, fig. 1). Intraclasts and oncoids are coated by similar crusts (Plate V, fig, 3) (Rüdiger, 1984). The clasts partly dolomitized during late diagenetic processes (e. g. Fn – II: 12,50 – 12,70 m; and Fn – III: 6,94 – 7,18 m).

3. Resorbed surfaces indicate zones, which were above the intertidal zone for longer times.

Facies III: Rudstone of mudstone clasts (intraformational breccia)

Macroscopic description: White to grey, mostly sparitic, calcareous matrix contains angular, grey or black intraclasts. Their diameter mostly ranges between 1 – 1,5 cm, but smaller, 0,5 cm and larger, max. 10 cm intraclasts also occur (Plate IV, fig. 1 – 2). Where the yellowish brown, micritic, dolomitic matrix appears, there are some larger (2 – 3 cm) gastropods and bivalves. There are frequent angular voids of 2 – 3 mm in size, filled by calcite. These layers overlay surfaces, which were affected by multiple solution and covered by thin, green clay film, wedging out within a short distance. Some zones contains intraclasts oriented by tectonic stress.

Microscopic description: Intraclasts with sparitic matrix. Intraclasts form 30 – 40% of the rock. The rock was separated into three groups according the colour, quality, quantity and size of the intraclasts.

Facies III/a: The intraclasts are micritic or oncoidic limestone without biogenic fragments.

Facies III/b: There are less than 10% biogenic components (Solenopora, Echinodermata) in the intraclasts.

Facies III/c: There is 5 – 10% bioclast (Solenoporaceae, Codiaceae, Gastropoda, Bivalvia fragments and echinoderm fragments) besides the intraclasts. The larger intraclasts of several cm in diameter are made of two limestone types: the first is more rich in fossils with micritic matrix, the second is fossil-poor, with sparite matrix.

Interpretation: Sediment reworked by wave action and deposited in tidal channels (e.g. Fn – II: 7,25 – 7,40 m; 8,25 – 8,38 m).

Facies IV: Floatstone made of mudstone clasts

Macroscopic description: The matrix is bluish grey limestone. It contains light grey, often dolomitic (1 – 4 mm) and black (1 – 8 mm), flattened intraclasts arranged in bands. (Plate III, fig. 2). The bedding surface shows isometric intraclasts of 0,2 – 1,5 cm diameter. Size range of the clasts commonly grows towards the bedding surfaces, showing less and less rounding. There is a black crust along bedding surfaces and on the bottom surface of the intraclasts, rarely coating the grains.

Microscopic description: The microfacies is varied. Most frequent are the micritic and sparitic lenses arranged in elongated bands. The micritic field contains dark grey and black, strongly flattened intraclasts. Rare echinoderm fragments occur in the matrix; their outline is followed by the parallel micritic and sparitic bands (Plate III, fig. 4). Where the micritic matrix dominates, it forms coherent layers. Its oriented texture and the folding of calcite veins were made by tectonic stresses.

Interpretation: Sediment deposited below wave base, in a quiet lagoonal environment, near the mouth of the intertidal channel.

The facies IV. frequently contains zebra limestone. (Plate VI. fig. 3).

Macroscopic description: Almost parallel, 4 – 5 mm thick, flat fissures occur in the rock every 4 – 5 cm. These are filled by two-generation calcite.

Interpretation (Flügel, 1982): Fissures are formed due to desiccation in the sediments deposited below intertidal zone. Calcite is formed during diagenesis.

Facies V: Plastoclastic floatstone

Macroscopic description: Light grey matrix with violet tint contains plastoclasts of variable size (2 – 15 cm) and quantity. These are brownish grey coloured (Plate III, fig. 3). Their material is similar to Facies type IV.

Interpretation: Unlithified calcareous mud have been redeposited into the depositional environment of the light grey lime mud. Deposited below intertidal zone, in an environment more quiet than that of type IV.

The originally lenticular clasts show chaotic mixing. Tectonic stress caused considerable elongation (e.g. Fn – II: 3,10 – 3,75 m; and at the S end of stage V of the quarry).

Facies VI: Mudstone

Facies VI/a: Homogeneous mudstone.

Macroscopic description: Light grey to grey, homogeneous limestone with a violet tint. A few large (8 – 15 cm) bivalve biomorphs were found; the cast was filled by yellowish brown, marly carbonate material (Plate VIII, fig. 4).

Interpretation: Deposited below wave base, far from the lagoon reef and from the shore, in somewhat more deep environment. (E.g.: Fn – II 0,00 – 1,10 m; 6,32 – 6,60 m; and Fn – IV: 14,80 – 15,50 m). Microlaminated mudstone. Facies VI/b:

Macroscopic description: Microlaminated limestone made of alternating 3 – 5 mm thick light and dark grey laminae.

Interpretation: Deposited below wave base, in a quiet environment.

This rock forms the uppermost beds exposed by the quarry. (Fn – IV 15,50 – 17,50 m).

Facies VII: Bioclastic floatstone – rudstone

Facies VII/a: Mixed bioclastic floatstone-rudstone. Macroscopic description: Light grey limestone with white rounded spots of 0,5 – 2 cm diameter (possibly recrystallized coral fragments). The matrix contains mm-size mollusc shell fragments and tiny echinoderm fragments. Microscopic description Bioclasts without any ordering, contacting each other (40 – 50% of the thin section), in micritic – rarely grainstone – matrix. In order of frequency: Solenoporaceae, Codiaceae, echinoderm plates, gastropods, bivalves, sphinctozoans, and other sponges (Plate VII, fig. 1 – 4).

Interpretation: Deposited near a reef, in a lagoon; besides the autochthonous fossils large quantities of allochthonous biogenic clastics have been deposited. The *Stylothalamia dehmi* OTT (described by S. KOVÁCS) found in this facies indicates a Ladinian-Carnian age (Plate VII, fig. 3 – 4). The most fossil-rich level was observed at the lower third of the Ist group of beds, in the Ist stage of the quarry (360 m a.s.l.).

Facies VII/b: Coral fragment floatstone-rudstone. Macroscopic description: Alternating 2–40 cm thick beds with coral fragments and 5–10 cm thick micritic layers. The former is white to light grey limestone, with a frame made of parallel oriented, 0,5×4 cm sized coral branch fragments contacting each other. Its micritic matrix contains 1–2 mm sized coated intraclasts and mollusc fragments. The clasts are coated by a tenth of a millimetre thick white crust.

Interpretation: The large quantity of coral debris was transported into the lagoon by a strong current coming from the reef. This level contains the allochthonous ammonoids.

Its sole occurrence is at the upper part of the sequence, in the Fn–IV profile between 5,4–14,4 m.

4.3. Facies types in the Felnémet quarry

This sequence of ca. 350 m thickness has been deposited on a permanently subsiding platform, surrounded by coral and sponge reefs and moving calcareous sand dunes, lying far from any dry land. It is indicated by the very low terrigenous content and the rare occurrence of marly rocks and clay films. The reef protecting the lagoon is poorly exposed: its sequence is described from its fragments intercalating with the lagoon sediments and from the exposed sequences of the surrounding area (borehole F–8, Mész valley, Felsőtárkány quarry).

The I. group of beds is very weakly bedded, white, homogeneous limestone. It was deposited in a near-reef, lagoonal subtidal environment, supported by the appearance of redeposited fiossils (see under 4.1.).

The II. and III. group of beds were deposited in the far-reef environment of the lagoon. The conspicuous cyclicity was caused by frequent change of sediments deposited below wave base, in the intertidal and in the supratidal zones (see 4.1.). The grey colour of the beds becomes more enhanced upwards, the intraclasts grow upwards in size become less rounded and show greater enrichment upwards. Also the dolomite content increases upwards. All these features are caused by the gradual decrease of water depth. The intertidal zone is indicated by algal mats, intertidal channels and (in the lower part of the group of beds) by intercalation of calcareous sand. The supratidal periods are characterized by resorbed surfaces, desiccation cracks, with synsedimentary and/or sparitic infill and vadose levels.

The II. group of of beds is more variable sediment, had been raised to the supratidal zone more frequently, while most of the III. group of beds is a more "regular" cyclic sediment. These groups of beds are poor in fossils. A violet-tinted light grey facies, deposited in a quiet, subtidal zone is frequent.

In the lower part of the IV. group of beds we can observe again the results of a sedimentation similar to the more shallow water, and more variable characters of the II. group of beds. A sudden change in environmental factors is indicated by the appearance of coarse brecciated, limestone, then by a limestone rich in coral fragments (see under 4.1.). This might have been caused by the destroy of the coral reef which previously protected the lagoon from intense wave action. This hypothesis is further corroborated by the occurrence of "exotic" ammonites.

The uppermost beds of the sequence indicate the recovery of the quiet, subtidal lagoonal environment.

5. Felnémet-8 borehole

Locality: eastern side of Berva-bérc and Cseres-bérc, in the saddle between points 512 and 508. The continuous carbonate sequence is between 78 – 198,6 m

5.1. Facies types of Felnémet – 8 borehole

Facies I: Grainstone/rudstone with algal and mudstone intraclasts

Dominant rock type in this sequence.

Description: A light to medium grey matrix contains 1 to 10 mm flattened, slightly rounded intraclasts, with a thin light grey crust at the upper part of the borehole. At the lower part of the borehole (below 140 m) frequent black coating of the grains were observed. The intraclasts are mostly graded – rarely show reverse grading – some cm thick cycles may be observed, frequently bearing stylolitic boundaries. Thin, homogeneous intercalations were observed too (Facies III). Dip of the beds changes between 0 to 30°, indicating cross-bedding. Rare algal and molluscan cross-sections were observed, too.

Microscopic description: A sparite matrix contains dark grey, micritic, rounded mud lumps of less than 2 mm in diameter and rounded intraclasts and biogenic detritus of 2 to 4 mm in diameter (40 – 60%). 60% of the larger intraclasts are made of algae, while 40% are made of micritic limestone (Pl. XI, fig. 1). Frequent micritic coating, indicating the activity of boring organisms, were observed. The fossil content ranges from 5 to 20%: algae (Solenoporaceae, Codiaceae), Echinodermata, Gastropoda, Foraminifera, Mollusca, Ostracoda and echinoid spines. Dogtooth cement coating the intraclasts was observed frequently, as well as geopetal structures. The rock bears an oriented texture due to pressure load (Pl. XI, fig. 1).

Interpretation: The sediment was deposited under constant wave motion: the strong current activity winnowed the micrite from among the grains (6. facies of Wilson). It was a calcareous sand dune moving on a plateau margin. The reverse grading was made by the effect of the "kinetic mesh" (Flügel, 1982) (e.g.: 107 – 108,60 m; 120,40 – 121,50 m; 146,0 – 153,0 m; 169,5 – 173,0 m; 181,5 – 188,5 m)

Between 103,0 – 169,3 m a late diagenetic dolomitization of facies type II was observed. CaO – MgO ratio varies from 34 : 19 to 52 : 3 in the samples.

Macroscopic description: The groundmass is yellowish brown to brownish grey, the fissures are filled by a micritic, marly sediment of yellow to pink tint. The larger intraclasts are coated by one- or multi-layered yellowish crust.

Microscopic description: The groundmass is dolomitic in spots. The larger intraclasts (1 to 2 cm) are surrounded by dolomite rhombohedra less than 1 mm in size (Pl. XI, figs. 2–3).

Interpretation: The dolomitized section indicates a hypersaline environment, due to a late rise of the sediments. Mg-rich solutions percolated in the sediment, dolomitizing the porous calcareous sand.

Facies II: Grainstone with mudstone intraclasts

Macroscopic description: Grey, homogeneous limestone. Light grains, less than 1 mm in size can be found in the matrix. Several birdseye voids have been observed, ranged in 45° angles.

Microscopic description: Mud lumps, less than 0,2 mm in diameter, in sparite cement, displaying close packing. (Plate XI, fig. 2). Only 1–2% fossil fragments: gastropods, algae, molluscs and echinoderms.

Interpretation: Deposited in an environment similar to that of facies I, but current activity was weaker (e.g. 87,2 m).

Facies III: Homogeneous mudstone

Light grey to grey limestone, enclosing thick-shelled, double-valved Bivalvia sections (7–8 cm diameter) and some gastropods. Rarely clasts, smaller than 1 mm, are enriched in some levels, showing transition towards facies type II. In the lowermost part of the borehole, below 180 m, frequent violet-tinted light grey, homogeneous limestone occurs.

Interpretation: Quiet lagoon sedimentation below wave base; unfrequent changes in environmental energy. (E.g. 115,5–115,75 m; 160,75–161,05 m; 180,30–181,35 m;

Facies IV: Bioclastic, intraclastic rudstone/floatstone

Macroscopic description: Yellowish brown, dolomitic limestone: Alternating 1–3 cm thick sparitic and micritic layers, separated by discordance surfaces. 20–30% yellowish brown to brownish grey, dolomitic, angular intraclasts occur (2 mm to 2 cm in diameter) (Pl. XII, fig. 1). In some 5–20 cm thick beds sudden enrichment of cm-sized fossil fragments were observed (thick-shelled bivalves, corals, algae), together with the enrich ment of intraclasts.

Microscopic description: Fossil and micritic limestone fragments in micritic or sparitic matrix. The biogenic components are mostly algae: *Griphoporella gümbeli* (SALOMON)PIA, other daysycladaceans, *Parachaetetes*(?), but some gastropods, foraminifers and corals also occur. The micritic groundmass contains 1–2 mm sparitic void infills arranged in bands.

Interpretation: Deposited in a well protected area between moving calcareous sand ranges and the reef, below tide level. The fossil *Griphoporella gümbeli* (SALOMON)PIA indicates Ladinian age. The dolomitic layers rich in fossil fragments probably indicate storm events overrunning the reef and transporting its material to the lagoon. (E.g. 78,0 – 79,0 m; 114,4 – 114,5 m).

5.2. Facies changes in Felnémet – 8 borehole

Most of the profile is dominated by grainstone, rudstone and floatstone. There are no

- algal mats,
- deposits of intertidal channels,
- vadose pisoids,
- and levels rich in reef detritus.

Most of the profile have been deposited in the environment of calcareous sand banks (WILSON 6;). The depositional environment has been shifted to deeper, more quiet environments between the sand banks and the reef, for short times. This occurred mostly above and below the dolomitic section. The group of layers below 170 m is similar to the clastic layers of Felnémet quarry. The layers made of 1 – 2 cm bioclasts and intraclasts were transported by storm tides. There are dolomitic layers frequently together with synsedimentary breccias between 103,0 – 169,3 metres. These beds indicate repeated regression. The area emerged above sea level repeatedly, indicated by thin, violet-red clay films on stylolitic surfaces (120 – 135 m), and by late diagenetic dolomitization.

Age: Ladinian, indicated by the alga *Griphoporella gümbeli* (SALOMON) PIA 1920, found between 114,4 – 114,5 m. (Plate XII, fig. 4).

6. Felsőtárkány quarry

The quarry is situated NW of the village of Felsőtárkány, at the southern entrance of Mész Valley (Mészvölgy). The exposures are poor, the quarry walls are mostly covered by scree.

6.1. Sequence of the Felsőtárkány quarry

Cycle members observed in the profiles frequently wedge out within a distance of 4 – 5 m. There are two rock types on the profiles, alternating with each other.

Facies I: Coral framestone with wackestone-floatstone matrix

Macroscopic description: Light grey. fossil-rich limestone of 1 to 4,5 m thickness. The fossils are mostly coral fragments; rarely 30 × 15 cm autochthonous coral colonies can be observed. (Plate XII, figs, 1 – 3). Frequent 1 × 1,5 cm echinoid spines, sponges (Pl. XIII, figs. 1 – 2), gastropod and other mollusc fragments. Characteristic 1 × 2 cm angular voids occur, filled by two generations of calcite cement.

Microscopic desription: 70 - 80% of the biogenic components in the micritic matrix are recrystallized corals. Besides the fossils mentioned in the macroscopic description there are ostracods, algae, brachiopods and foraminifers.

Interpretation: Typical reef facies with coral frame.

Fossils:

Sphinctozoa:

Stylothalamia dehmi OTT, Ladinian-Carnian
Colospongia dubia?
Colospongia sp.
Cryptocoelia sp (Pl. XIII, fig. 3.)
Cryptocoelia n.sp. (Pl. XIII, fig. 4)

Algae

Griphoporella gümbeli (?) (SALOMON)PIA, Ladinian(?)

Facies II: Rudstone with reef fragments

Dark grey to grey, coarsely brecciated limestone, of 1,2 to 4 m thickness. The dark grey matrix contains light grey to grey, unsorted, angular intraclasts. Rarely the grain size of the clasts decrease upwards. Clast size: 2 to 20 cm, rarely 40×60 cm clasts and one 200×75 cm clast occur. The clasts form 25 to 65% of the rock. The space among the intraclasts is filled by dark grey, occasionally synsedimentary, coarse grained calcareous material with frequent slumps. Margins of the larger (10 – 15 cm in diameter) voids are formed of black, radial calcite, while the inner parts are filled by white, coarse calcite crystals (Pl. XV, fig. 2). The components are ranged into two groups:

1. Intraclasts:

a) Bioclastic wackestone: Micritic matrix contains rare biogenic fragments and micritic mud lumps. Fossils: echinoderm fragments, bivalve, gastropod, echinoid spine, coral branch.

b) Bioclastic-peloidic grainstone/wackestone. The groundmass is mostly sparitic, rarely micritic. The components: 20 – 40% peloids of 0,1 to 0,2 mm in diameter, echinoderm fragments, alga, dasycladacean, small gastropod, bivalve.

2. The space among the intraclasts is filled by sparitic calcite.

6.2. Facies interpretation of the Felsőtárkány quarry

Its facies is different from the Felnémet quarry and the Felnémet – 8 borehole. The two facies types described above alternates in 1 – 4 m thick, wedge-shaped layers. The members of the cycle are thicker than in the lagoonal facies. Two interpretations are discussed below:

a) Reef.

Brandner and Resch (1981) describe a cyclic reef growth. The cycle begins after a sudden subsidence followed by scree deposition. This is followed by an autochthonous reef body. Its growth is intercepted by the next, sudden transgression.

b) Sediment of the outer reef slope

There is no great difference in depth between the reef and the bottom of the slope, since no pelagic sediments have been observed. The life of the autochthonous fossil community (facies I) is regularly intercepted by debris flows (facies II).

We propose to accept the first version.

7. Exposures in the surroundings of the two quarries.

Mész valley gorge: (Localities 1 to 7): White to light grey limestone fossils enriched in some levels (corals and somewhat less echinoderm fragments). Autochtonous coral colonies were observed on several larger (a few m^2) surfaces. Cm-sized, angular intraclasts are enriched in frequent spots. Irregular voids, filled by dark grey calcite are frequent too.

The scree at the foot of the wall contains large amounts of corals, bivalve and gastropod fragments.

The localities at Mész valley gorge were deposited in a reef (reef core plus the surrounding reef detritus) environment.

Above Mész valley, cuts of a forest road 150 to 200 m W of the valley (localities 121 to 126):

White to light grey, homogeneous, weakly bedded limestone with a few coral, echinoderm and sponge fragments. The bed-parallel coral fragments reach their greatest abundance at locality No. 124: ca. 70%, but their amount gradually decreases towards north and suddenly decreases towards south.

Road cuts of the forest road between Alsó-Nyergeskő-lápa and Finomszerelvény-gyár factory (localities 12 to 21):
Facies:

— Grey limestone with 2 – 3 cm large angular intraclasts, and 4 – 5 cm dark grey, sparite filled voids among them.

— White to light grey, fossil-rich limestone (mostly autochthonous corals, sphinctozoans, bivalves, gastropods and echinoderm fragments). Few 5 – 7 sm sized voids filled by sparite cement.

— Fossil-poor, light grey, homogeneous limestone.

Road cuts between the "Valley of spoil-banks" to Bervabérc and Cseresbérc, eastern slope (localities 22 to 27:

The exposures are similar to the moving sand dune facies of Felnémet -8 borehole.

Ridge between Bervabérc and Cseresbérc (localities 28 and 29):

Dark grey to grey limestone with intraclasts up to 3 – 4 cm. Fossils: frequent 2 – 4 cm gastropods, rare corals and bioclasts. Lagoon with quiet water.

Ridge of Bervabérc at the NE corner of Felnémet quarry (localities 101 to 103 and borehole F – 6):

The light grey to grey limestone of lagoonal facies is frequently of lighter colour, with rounded intraclasts (less than 5 mm). Rare fossils: echinoderm and coral fragments, gastropods.

The steep NW slope of Bervabérc and Cseresbérc (localities 109 to 112 and 114) and Nyergeskő-orom (localities 129 – 132):

White to light grey, homogeneous, thick-bedded limestone, extremely poor in fossils.

Ridge of Bervabérc and Cseresbérc and Hosszú Galyatető (localities 104 – 107):

White to light grey, homogeneous, thick-bedded limestone; frequent coral and echinoderm fragments, gastropods. At localitiy No. 107 reef core with abundant coral colonies was observed in the thick scree. It may be a patch reef.

300 m to the lower entrance of Berva valley, south of the former lime-kiln (locality 120):

Dark grey, bioclastic and intraclastic limestone. Most of the bioclasts are algal debris (see under point 10).

8. Geochemistry

The strongly deformed texture indicates the possibility of a very low grade metamorphism. X-ray examination of five samples from Felnémet and five samples from Felsőtárkány was made by P. ÁRKAI.

Insoluble residue of the rocks are mostly below 0,5%. The samples are almost totally made of $CaCO_3$.

The minerals of the insoluble residue in decreasing abundance: quartz, plagioclase, sericite, kaolinite, pyrite, goethite, K-feldspar and chlorite. Illite was found in two samples only. These samples contain illite-kaolinite. Crystallinity degree of illite is 0,808° 2 Θ, indicating the diagenetic stage. It is also supported by the relatively high quantity of kaolinite.

While textural features show strong deformation, the rock did not suffer even very low grade metamorphism.

9. Palaeoenvironmetal reconstruction

The facies types were figured on a map and the following palaeoenvironmental model was established. Four facies types can be distinguished in the region.

a) *Felnémet quarry*

The first group of beds (0 to 85 m): barely bedded, white, bioclastic limestone was deposited in a lagoon, near the reef. The 85 – 355 m section of the quarry profile show cyclic deposition. There was almost no terrigenous influence. (See chapter 8). The sequence was deposited on a submarine plateau far from the dry land, first in a relatively deep, than a shallower than again in a somewhat deeper environment. Water depth changed between zero and some tens of metres.

On the ridge, NNE from the quarry, above the level of the fossil-rich, near-reef lagoonal facies (localities 101 – 107), there is a conspicuously fossil-poor, homogeneous sequence of considerable thickness (localities 108 to 132).

b) *Felnémet – 8 borehole and localities 22 to 26*. Calcareous sand moving on a plateau margin (Wilson 6). Water depth is generally above the normal wave base, in the breaker zone. The calcareous sand dunes might have reached the supratidal zone in a hypersaline environment for a short time. The exposures belonging to this facies belt surround the lagoon in a north – south belt. The northernmost exposures are in the surroundings of borehole F – 8. Its thin beds were observed in Felnémet quarry.

c) *Localities 1 to 7 and 12 to 21* indicate reef (Wilson 5) facies. These exposures are ranged in a several km long belt oriented north to south. The reef facies is represented by white to light grey rocks rich in corals, echinoderms, foraminifers and gastropods. Reef-core intraclasts are enriched in some levels.

d) *Felsőtárkány quarry*

Reef (Wilson 5) or fore-reef (Wilson 4) facies. This facies shows a conspicouous similarity to the cyclic reef evolution model of Brandner and Resch (1981).

The dark grey to grey reef detritus was deposited from debris flows arriving from the direction of the reefs, while the light grey, fossil-rich layers represent the autochthonous reef slope formed in quiet periods.

10. Fossils and age of the Bervavölgy Limestone Formation

10.1. Biostratigraphy

The list of fossils collected by our field work is listed by the localities, in the order of the facies types. The algae were determined by Olga Piros, the foraminifers by Anna Oravecz – Scheffer, the sponges by Sándor Kovács.

Lagoonal facies, southernmost exposure, locality No. 120 (see chapter 7):

Algae

Dasycladaceae

Teutloporella herculea (Stoppani) Pia	7
Diplopora annulata Schafhäutl	2
Griphoporella gümbeli (Salomon) Pia	
? *Physoporella* sp.	

Codiaceae
Solenoporaceae
Echinodermata
Gastropoda

I. group of beds in Felnémet quarry (see under 4.1.)

Algae

Solenoporaceae

Thaumatoporella parvovesiculifera (RAINERI)
(Pl. VII, fig. 1)

Porifera
Calcispongea
Sphinctozoa
Stylothalamia dehmi OTT 2
(Pl. VII, fig. 3–4)

Anthozoa
Echinodermata
Ostracoda
Gastropoda
Bivalvia
Brachiopoda

II. group of beds in Felnémet quarry (see under 4.1.)

Algae

Codiaceae (Pl. V, fig. 4)
Solenoporaceae (Pl. V, fig. 2)
Echinodermata
Gastropoda

IV. group of beds in Felnémet quarry (see under 4.1.):

Bivalvia

Megalodontida (?) section (Pl. VIII, fig. 4)*q*
Cephalopoda
Ammonoidea (Pl. VIII, fig. 2)
Ptychites group, section (Pl. VIII, fig. 1)
Ridge NE from Felnémet quarry (see under 7):

Ridge NE from Felnémet quarry (see under 7):

Algae

Dasycladaceae
Macroporella beneckei PIA
Macroporella spectabilis BYSTRICKY
Griphoporella sp.

Codiaceae
Solenoporaceae

Protozoa

Foraminiferida
Aulotortus sinuosus WEYNSCHENK 3
Gsolbergella spiroloculiformis (ORAVECZ – SCHEFFER)
Trocholina sp.
Ophthalmipora dolomitica ZANINETTI et BRÖNNIMANN
Earlandinita cf. *soussi* SALAJ

Hydrozoa

Anthozoa fragment
Echinodermata fragment
Gastropoda section
Ostracoda section

Felnémet – 8 borehole (see under 5.1.):

Algae

Dasycladaceae
Griphoporella gümbeli (SALOMON)PIA 1920
Pl. XI, fig. 1 2
Codiaceae
Solenoporaceae
Parachaetetes (?)

Protozoa

Foraminiferida
Triadodiscus eomesozoicus (OBERHAUSER)
Aulotortus sinuosus WEYNSCHENK 3
Ammobaculites cf. *corpulentus* EFIMOVA
Diplotremina astrofimbriata KRISTAN-TOLLMANN
Diplotremina sp.
Trochammina alpina KRISTAN – TOLLMANN
Duostomidae
Glomospira sp.
Glomospirella sp.
Ophtalmidium sp.

Anthozoa
Echinodermata
Echinoidea
Ostracoda
Gastropoda
Bivalvia

From the reef facies of Felsőtárkány quarry (see under 6.1.):

Algae

Dasycladaceae

Griphoporella gümbeli (?) (SALOMON)PIA

Porifera

Calcispongea

Sphinctozoa

Stylothalamia dehmi OTT

Cryptocoelia sp.

Cryptocoelia n. sp.

Coelospongia dubia (?)

Anthozoa

Gastropoda

Among the above listed fossils algae, foraminifers and sponges help to determine the age of deposition. The algae determined to the species level *(Diplopora annulata, Griphoporella gümbeli, Teutloporella herculea* and *Macroporella beneckei)* are characteristic for the Ladinian stage. The sponges *(Stylothalamia dehmi, Coelospongia dubia* (?) and *Cryptocoelia)* are Ladinian to Carnian and are the characteristic fossils of Wetterstsein reefs.

The foraminifer fauna indicates Ladinian age, but several species occur in the Carnian as well. The species *Earlandinita* cf. *soussi* SALAJ occurs in large numbers in the Carnian Tisovec Limestone, but rarely occurs in the Ladinian also. There is no species characteristic solely for the Carnian.

10.2. Former faunistic data

SCHRÉTER (1935) has described a rich fossil assemblage from Bervabérc and assigned it to the Ladinian.

BALOGH (1964) completed aerlier collections and ranged the fauna to Upper Ladinian – Carnian. After partial revision of the fauna (BALOGH, 1981), he ranged it to the Norian.

Compiling all available data we can say that the Bervavölgy Limestone Formation is of Ladinian age. There is no fossil proving Carnian age. The collected fossils are typical for the Westterstein Limestone, the Bervavölgy Limestone is herein ranged among the Wetterstein-type reefs.

10.3. Evolution

There is no enough data to reconstruct the detailed history of the Bervavölgy reef complex, therefore we propose a theoretical model only.

There are no Anisian formations in the examined region. The reef complex existed already in the Ladinian. This is unanimously proven by our biostratigraphical data (see under 10). The Ladinian age is also supported by SCHRÉTER (1935) and BALOGH (1964). According to Wetterstein-type analogues we suggest the existence of an underlying Anisian Steinalm limestone an an overlying Lower Carnian Wetterstein Limestone. The actual occurrence of these formations is to be proved as yet.

Up to now the only occurrence of Wetterstein Limestone is in the Silica Nappe of Bükk unit. SCHOLZ (1972) and KOVÁCS (1979) described an Anisian – Lower Carnian outer reef slope – reef – open lagoon complex. The Bervavölgy Limestone described in the present paper is the first Wetterstein Limestone occurrence of the Bükk Mts. and the southermost occurrence of the Inner West Carpathians.

11. Further tasks

1. Detailed survey of the region; age determination of the lowermost and uppermost parts of the sequence.

2. Tectonic investigations to determine the contact between the limestone and the surrounding formations.

3. Comparison of the Bervavölgy Limestone with the other limestone occurrence in the Southern Bükk Mts. (Subalyuk, Hór-valley, Répáshuta) of probably similar age and facies. It is to be determined that these parts of a carbonate shelf when did part and what kind of tectonic events positioned them in their present-day place. After the stratigraphic and structural investigations of the whole Mesozoic sequence in the Bükk Mts. the Wetterstein limestone can be placed to its proper position in the history of the Bükkium.

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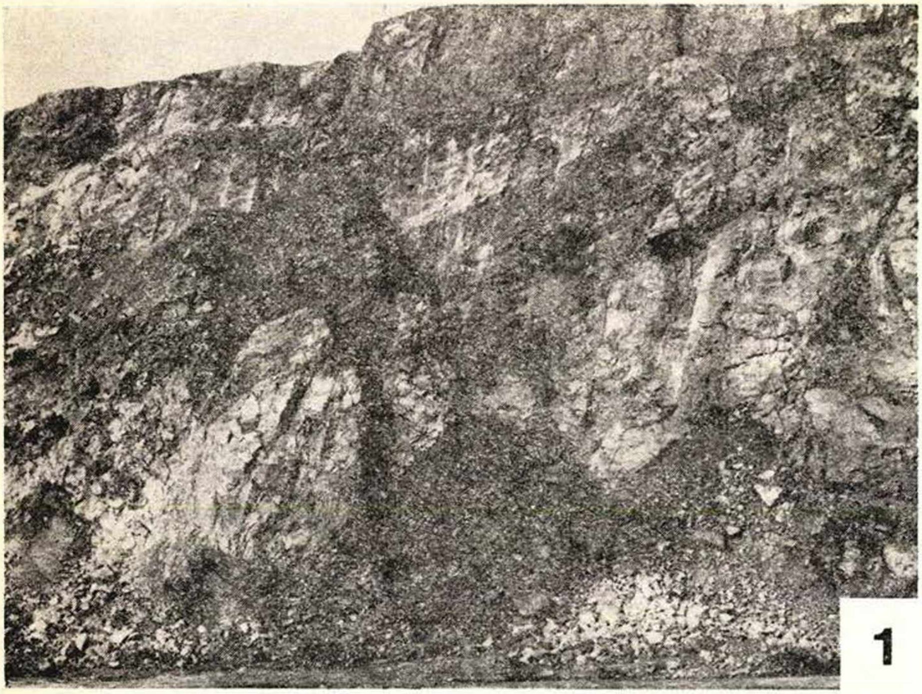

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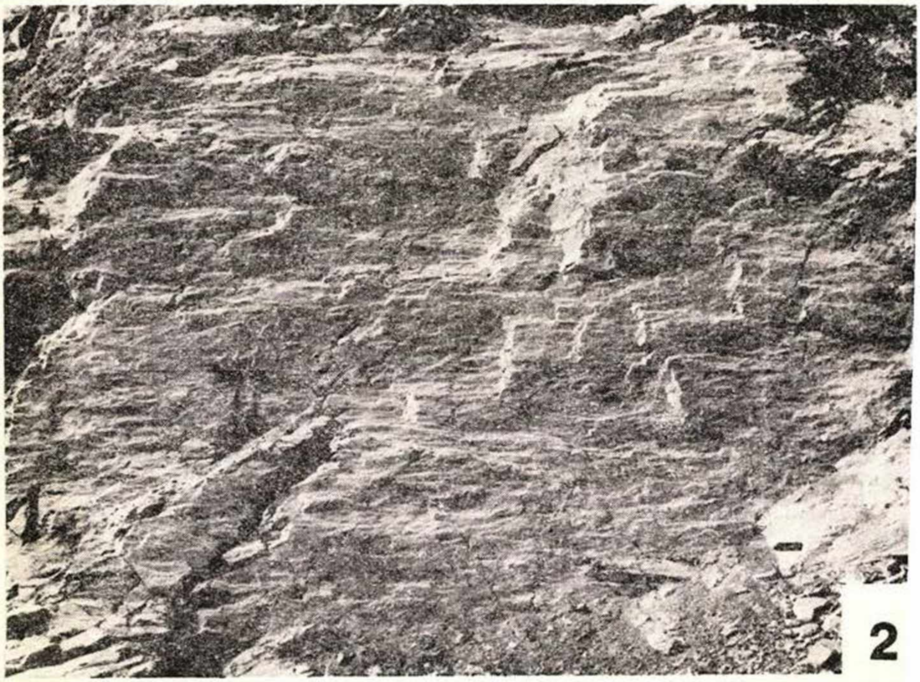

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PLATE I.

Felnémet quarry

1. Boundary of the homogeneous, light (I.) and the dark, cyclic (II.) group of layers. Middle of the 2nd level in the quarry. Height of the quarry wall: 40 m.
2. Large fault surface indicating horizontal displacement. Dip: 140/60°. Northern end of the 5th level of the quarry.

2

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PLATE II.

Felnémet quarry

1. Cyclic sequence characteristic for the deeper part of III. group of layers. Norther end of the 2nd quarry level. Height of the wall: 40 m.
2. Higher part of III. group of layers; the cycles are thicker and their colour is lighter than on fig. 1. Middle of 4th quarry level. Height of the quarry wall: 30 m.
3. The bed with small, black intraclasts (IV. facies) is overlain by algal mat, following a stylolitic surface (emersion?) (I. facies). Detail of fig. 2.

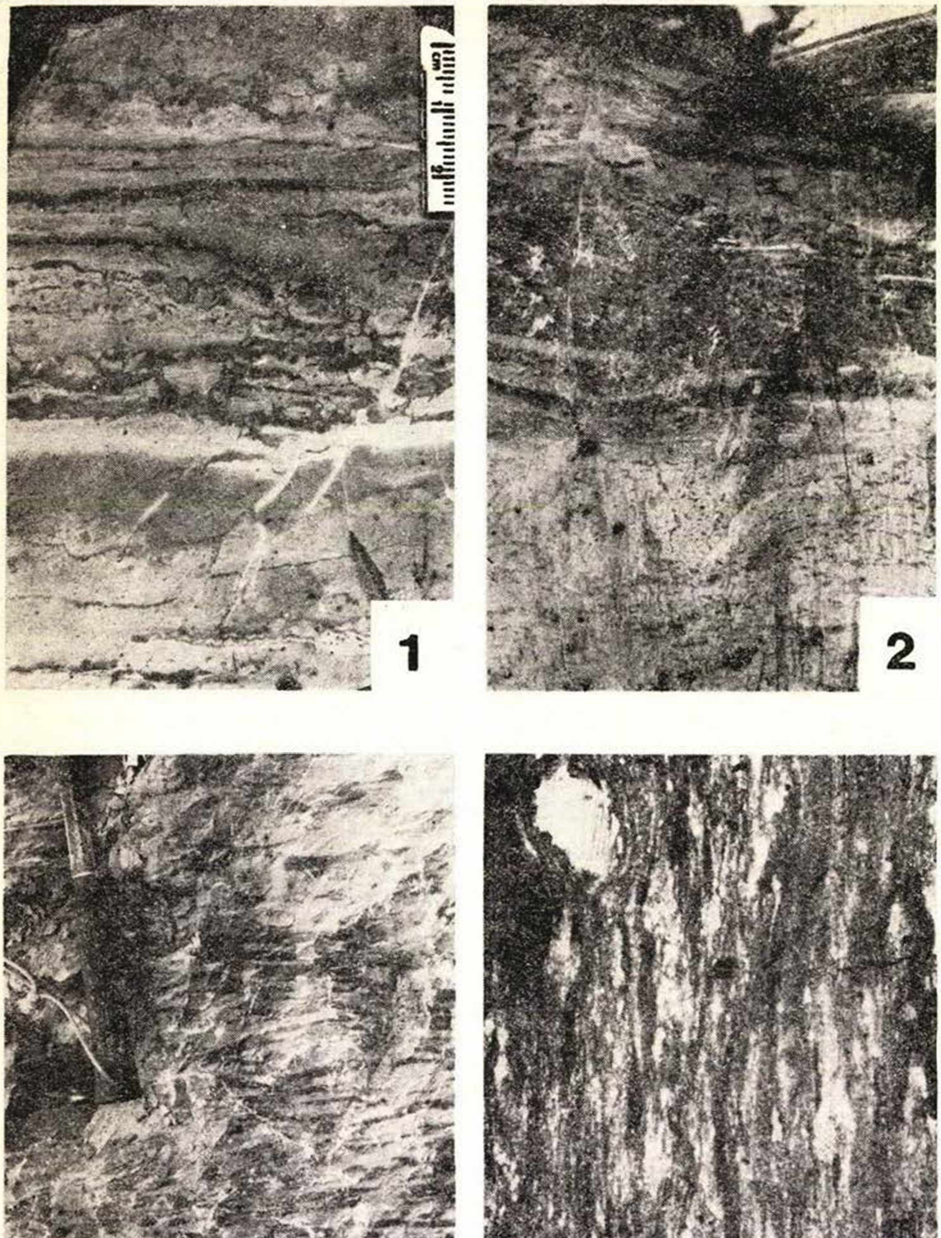

PLATE III.

Facies types in Felnémet quarry

1. Algal mat (facies I.), with brecciated levels, indicating emersion. III. group of beds. Locality: northern part of 2nd level in the quarry.
2. Algal mat (facies I) overlain by black intraclastic (IV) then by plastoclastic (V) layers, due to gradual deepening of the depositional environn.ent. III. group of beds. Northern end of 5th level in the quarry. Scree.
3. Plastoclastic limestone (facies V). Mixture of unconsolidated sediments of a subtidal lagoon. III. group of beds. Southern end of 5th level of the quarry.
4. Black intraclastic limestone (facies IV, see Pl. III. fig. 2) . The components are deformed due to tectonic stress, 12x

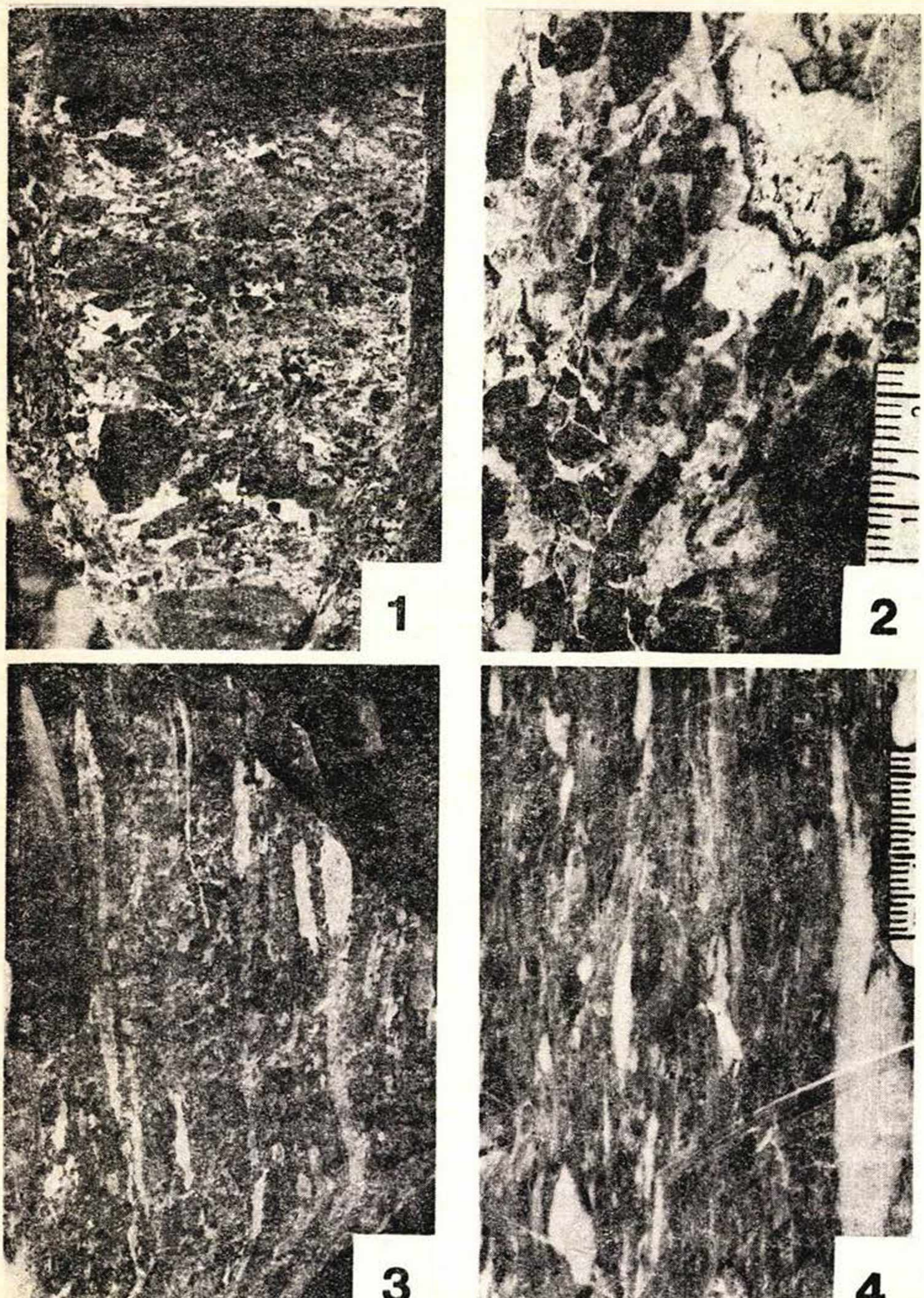
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PLATE IV.

Facies types in Felnémet quarry

1–2. Intraformational breccia with sparitic cement. Deposit of an intertidal channel (facies III). III. group of beds. Southern part of the 5th level of the quarry, scree.

3. Different intraclasts in micritic matrix. The originally flat intraclasts (from an intertidal environment) have been further flattened due to tectonic stresses. III. group of beds, scree.

4. Different intraclasts in micritic matrix; quiet environment. II. group of beds, southern end of 5th quarry level.

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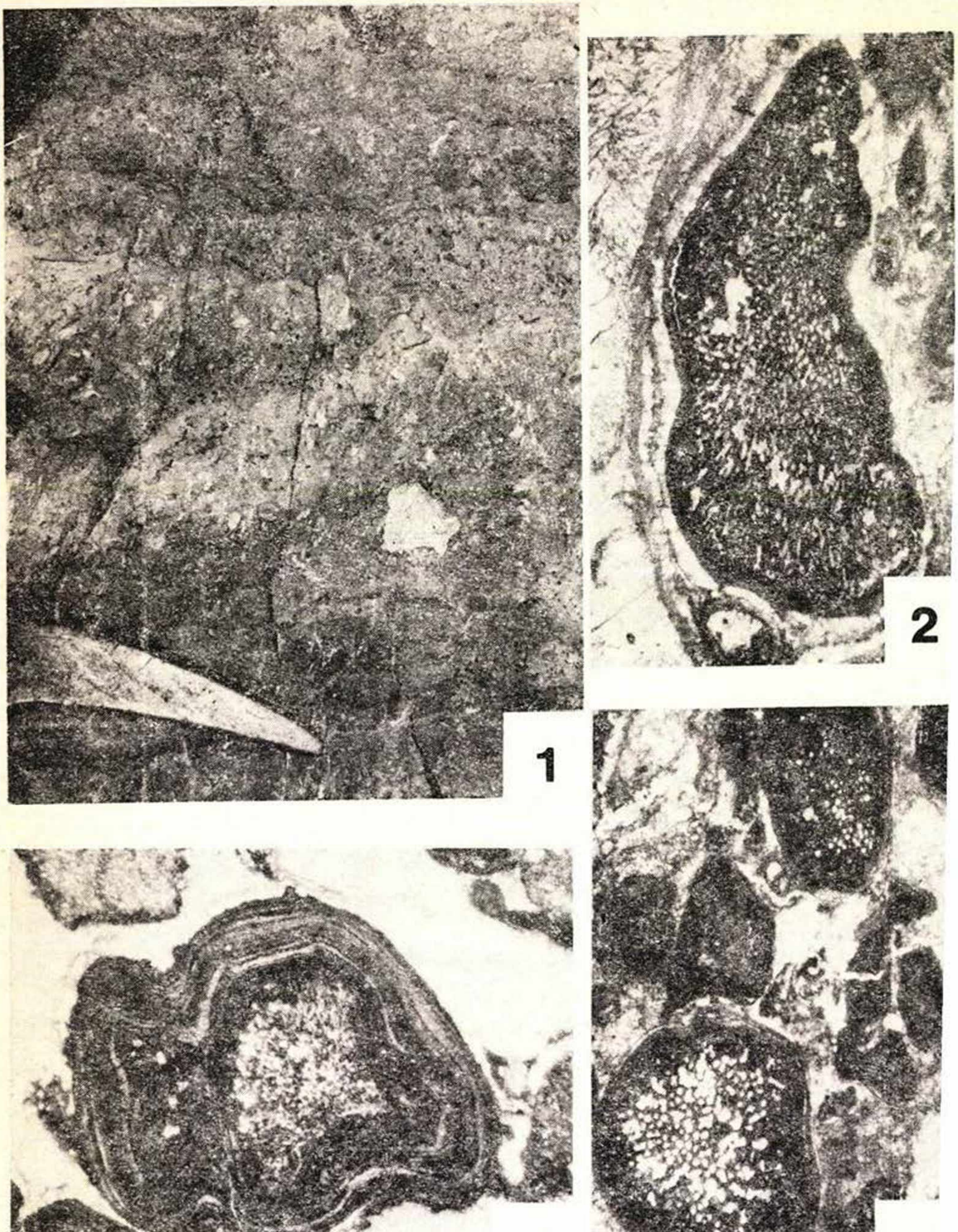

PLATE V.

Facies types of Felnémet quarry

1. Vadose pisoidic crusts, precipitated in the deeper part of the vadose zone. (facies IIb, profile Fn-III, southern part of 3rd quarry level).
2. Solenoporaceae (facies IIa) (III. group of beds, middle part of 2nd quarry level, scree). 8x
3. Solenoporaceae fragment with vadose pisoidic crust. (IIb facies, III. group of beds, 2nd level in the middle of the quarry, scree). 8x
4. Coated Codiaceae fragment (IIa facies, III. group, 2nd quarry level, scree). 8x

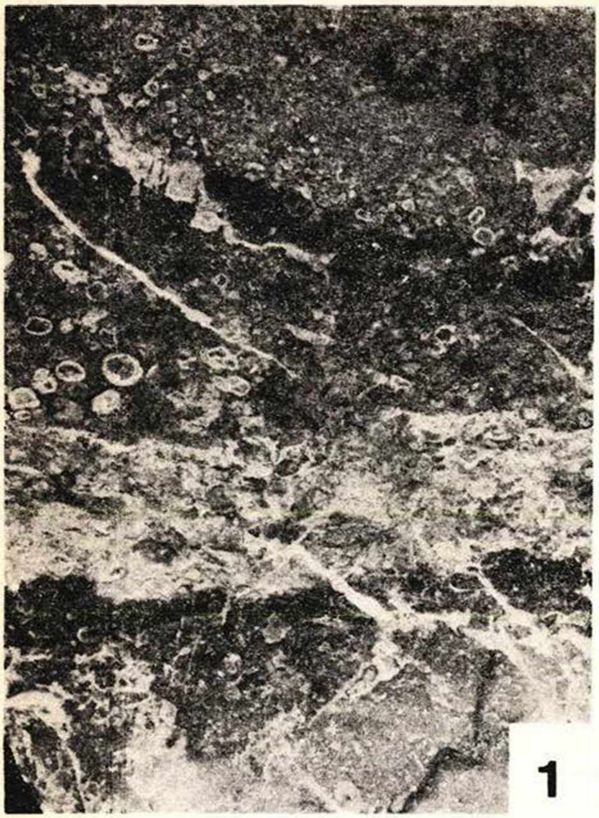

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PLATE VI.

Facies types of Felnémet quarry

1. Slightly graded beds made of rounded intraclasts with dolomitic coating. (III. group of beds, 5th quarry level, southern part, scree). Natural size
2. Tectonic strain directions of ooids enclose an acute angle with graded bedding. (facies IIa, III. group of beds, 2nd quarry level, middle part, scree).
3. Zebra limestone (IV. facies, III. group of beds, 5th quarry level, southern end).

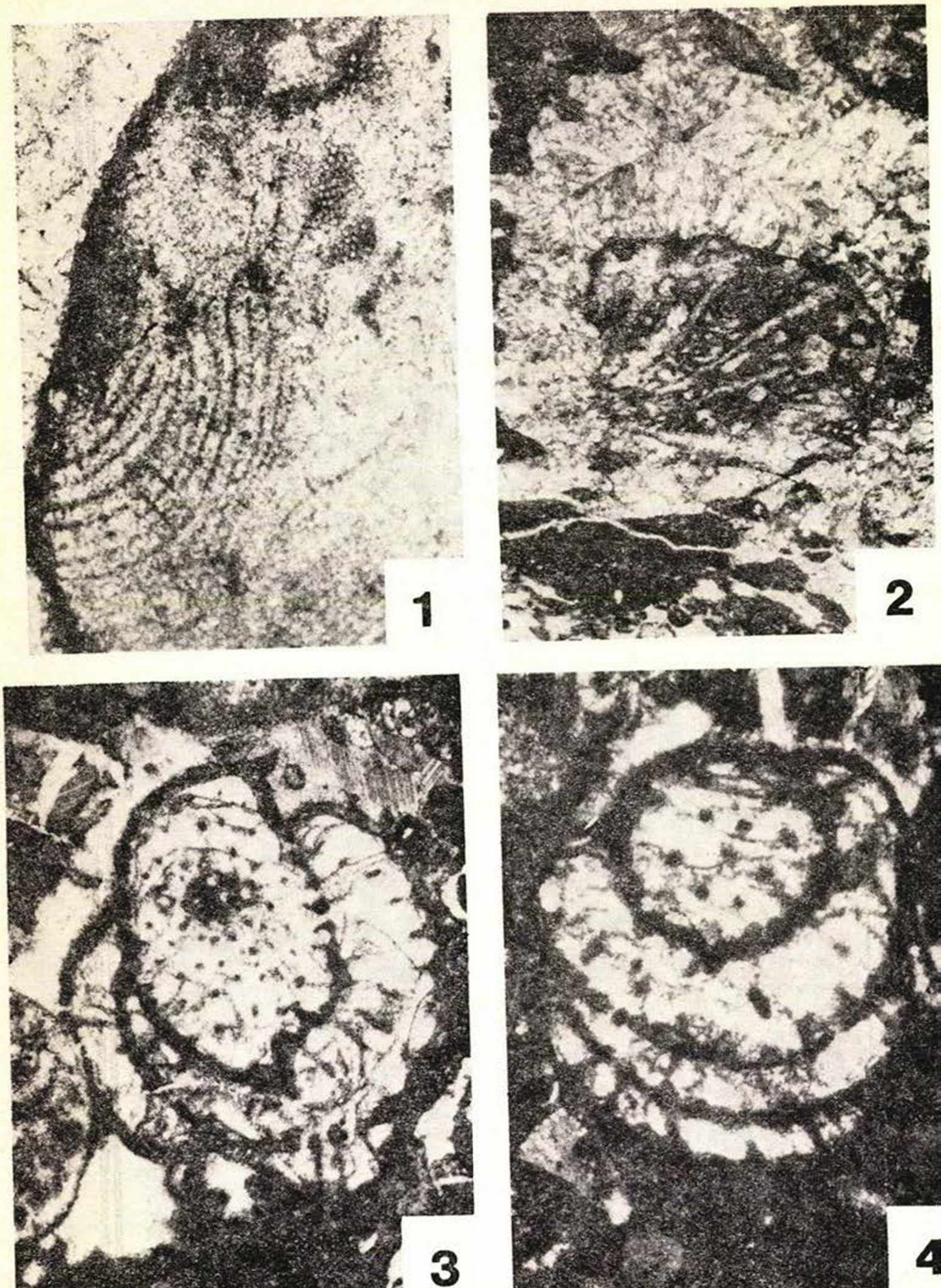


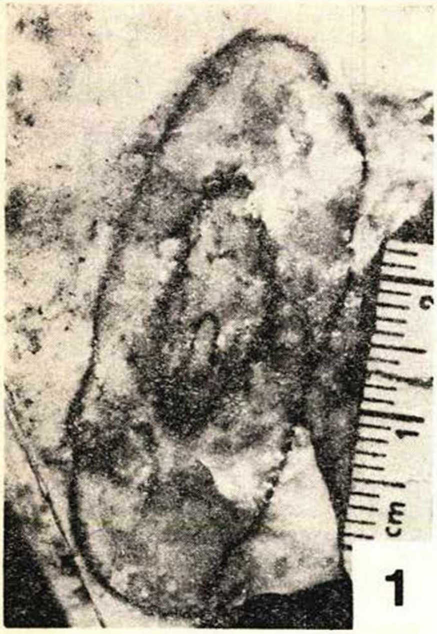
PLATE VII.

Fossils from Felnémet quarry

(VII. facies, I. group of beds, one-third of lst quarry level)

1. *Thaumatoporella parvovesiculifera* (RAINERI). 16x
2. Coral fragments in sparitic cement. 9x

3–4. *Stylothalamia dehmi* OTT. 13x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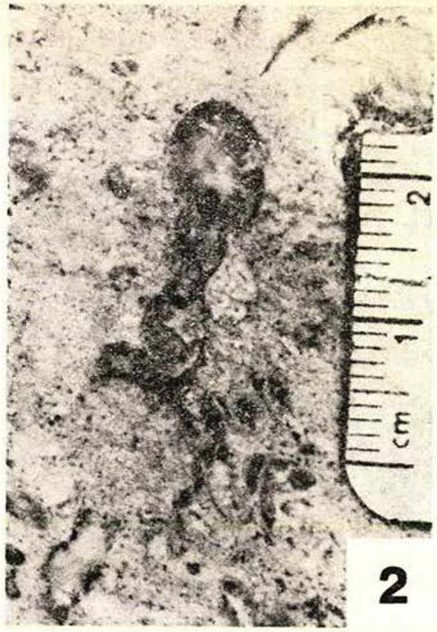
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PLATE VIII.

Fossils from Felnémet quarry

1. Ammonites section (Ptychites group). (From the light grey limestone of IV. group of beds, northern end of 4th quarry level, scree.)
2. Ammonites section from the dolomitic lenses of the IV. group of beds. Northern end of 4th quarry level.
3. Redeposited coral colony from the breccia level of IV. group of beds. Northern end of 5th quarry level.
4. Megalodontidae (?) section. The exsolved shell was filled by calcite spar then by dolomitic, micritic mud. (From the grey limestone of IV. group of beds, norhern end of 4th quarry level.)

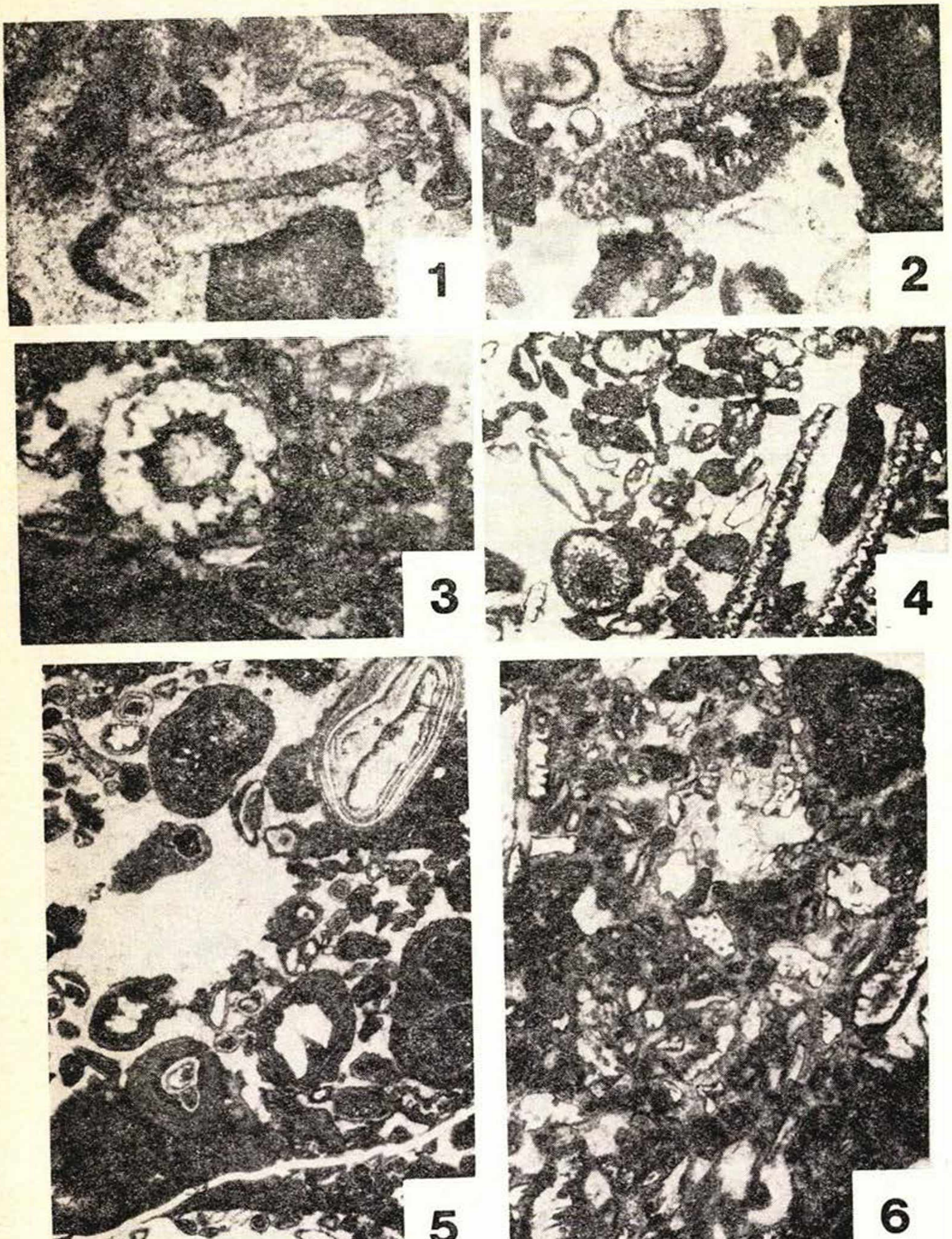
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PLATE IX.

Algae of the normal lagoonal facies

1. *Macroporella beneckei* PIA; locality 106. 8x
2. *Macroporella spectabilis* BYSTRICKY; locality 106. 8x
3. ? *Physoporella* sp. *Teutloporella herculea* (STOPPANI). Locality 120. 11x
4. *Griphoporella gümbeli* (SALOMON) PIA. Locality 120. 7x
5. Multiple coated bioclasts, mostly algal fragments. Locality 120. 8x
6. Angular algal fragment. *Thaumatoporella herculea* (STOPPANI), Codiaceae. Locality 120. 5x

10

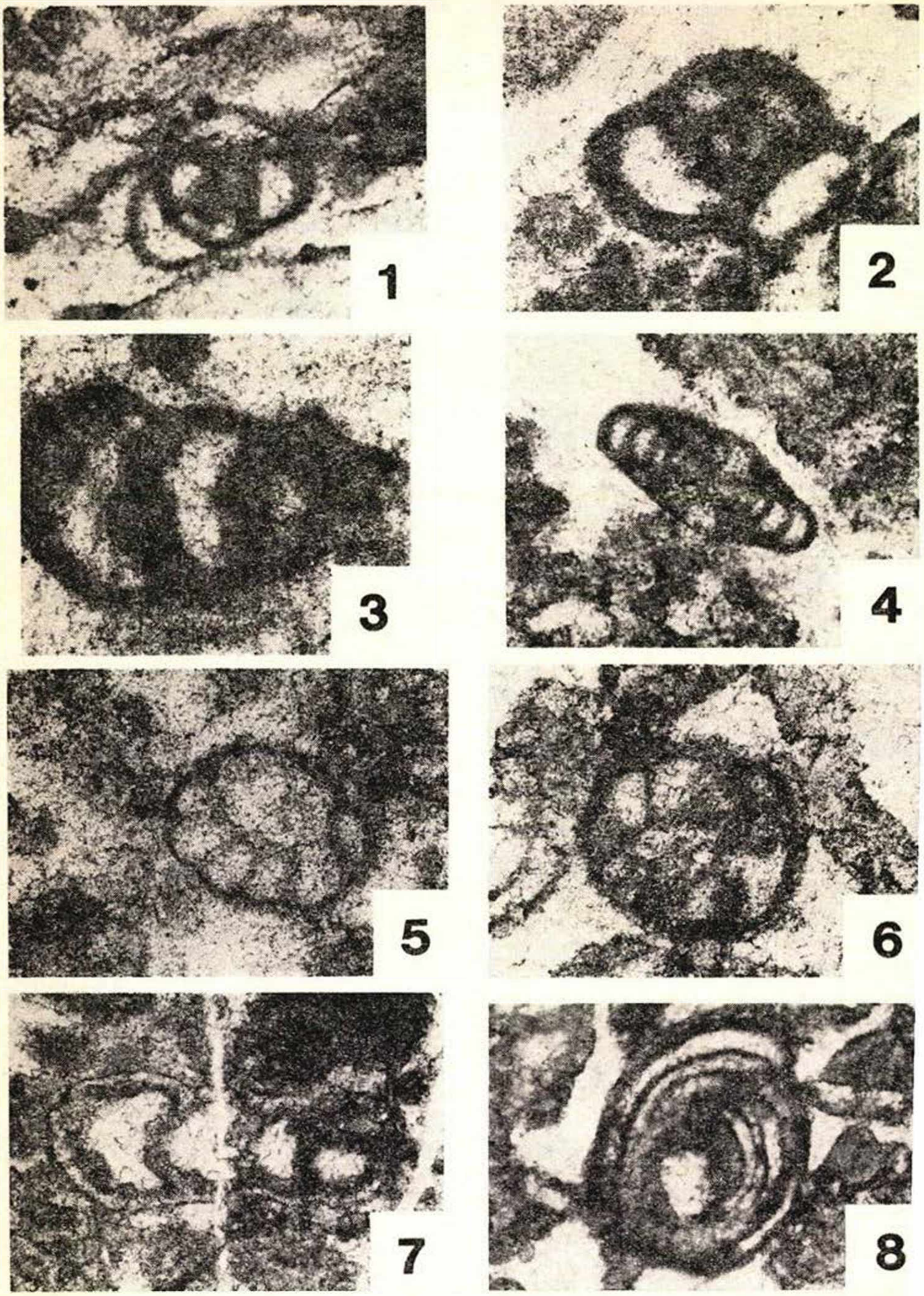

PLATE X.

Foraminifers

Foraminifers of the lagoonal facies

1. *Gsollbergella spiroloculiformis* (ORAVECZ – SCHEFFER). Locality 104a. 9x
2. *Ophtalmipora dolomitica* ZANINETTI et BRÖNNIMANN. Locality 106. 30x
3. *Earlandinita* cf. *soussi* SALAJ. Locality 106. 35x

Foraminifers of the plateau margin calcareous sand.

4. *Triadodiscus eomesozoicus* (OBERHAUSER). Locality: borehole F – 8. 114,4 – 114,55 m. 50x

5 – 6. Duostominidae. Borehole F – 8. 114,4 – 114,55 m. 50x

7. *Ammobaculites* cf. *corpulentus* EFIMOVA. Borehole F – 8. 114,4 – 114,55 m. 32x
8. *Ophtalmidium* sp. Borehole F – 8. 114,4 – 114,55 m. 11x

11

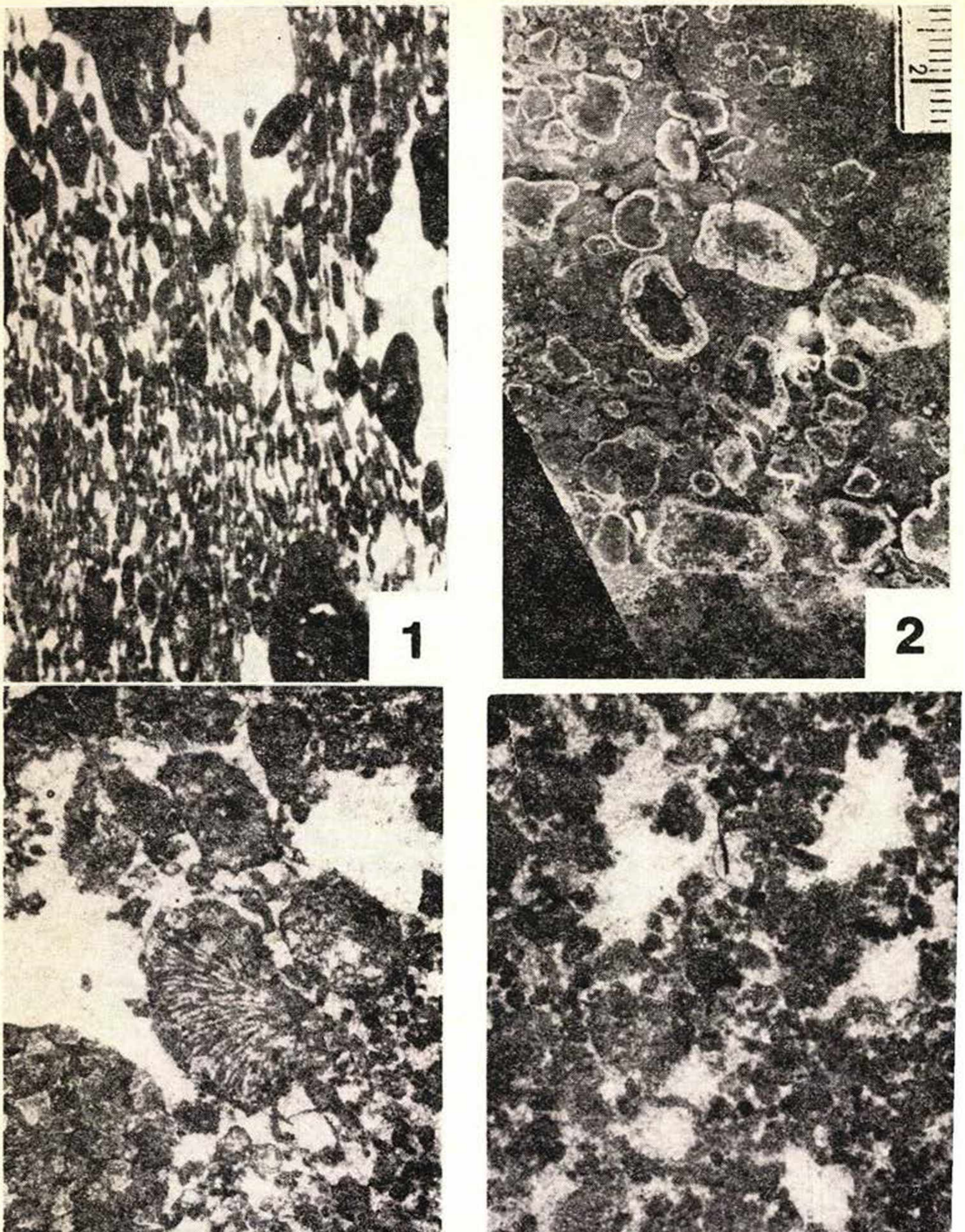

PLATE XI.

Borehole Felnémet – 8.

Plateau margin calcareous sand facies

1. Micritic mud lumps and biogenic fragments in sparitic matrix. II. facies, 180,8 m. 13x
2. Large rounded biogenic fragments (mostly algae) with dolomtic coating. I. facies, 103,0 m.
3. Thin section of fig. 2. 9x
4. Small micritic mud lumps in sparitic matrix. II, facies, 87,2 m. 19x

12

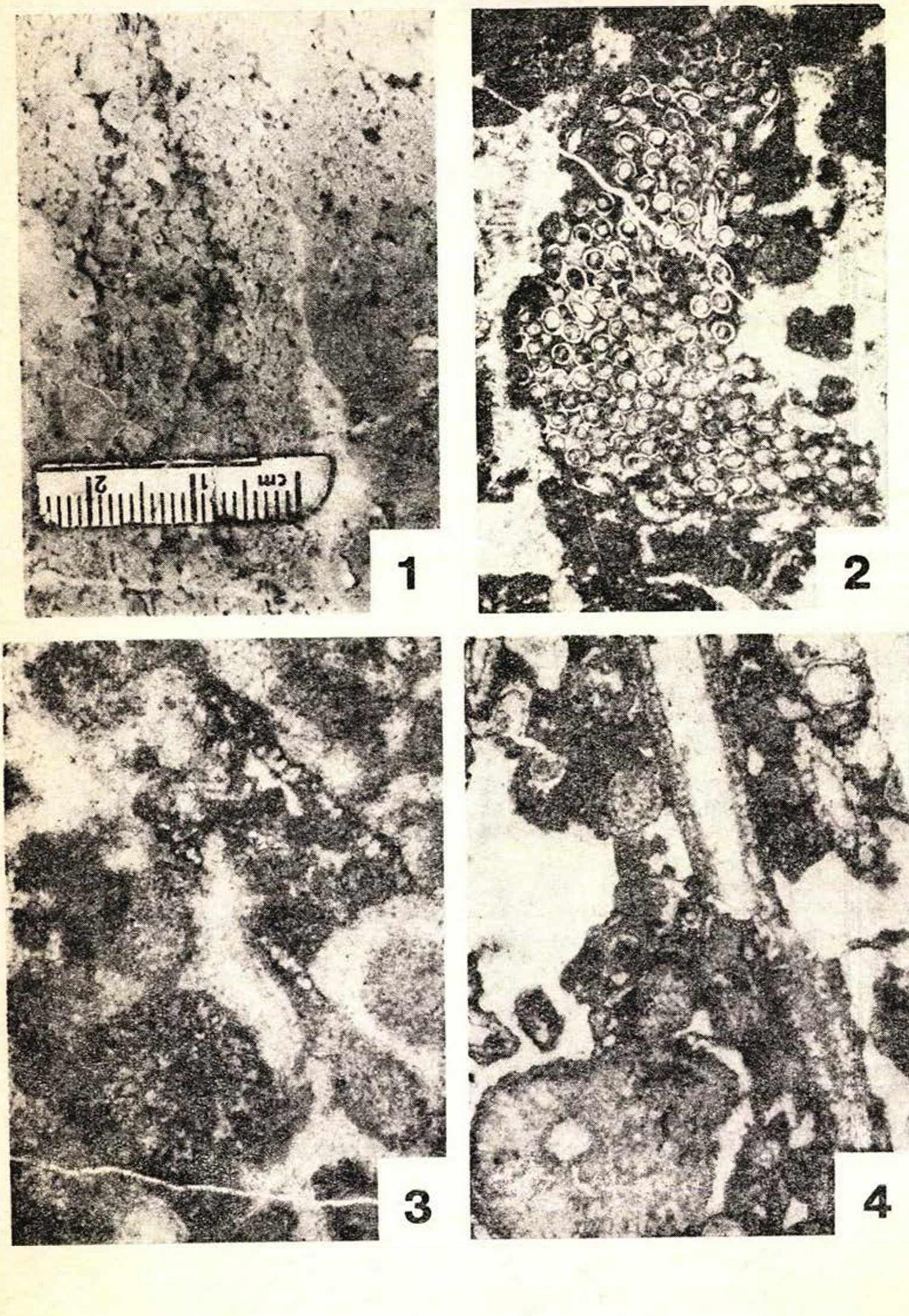

PLATE XII.

Fossils from Felnémet – 8 borehole

1. Rudstone with algal fragments, IV. facies F – 8, 114,4 – 114,55 m.
2. Microproblematicum? F – 8. 174,5 m. 8x
3. *Griphoporella* sp. Codiaceae. F – 8. 197,4 m. 13x
4. *Griphoporella gümbeli* (Salamon) Pia, F – 8, 114,4 – 114,55 m. 9x

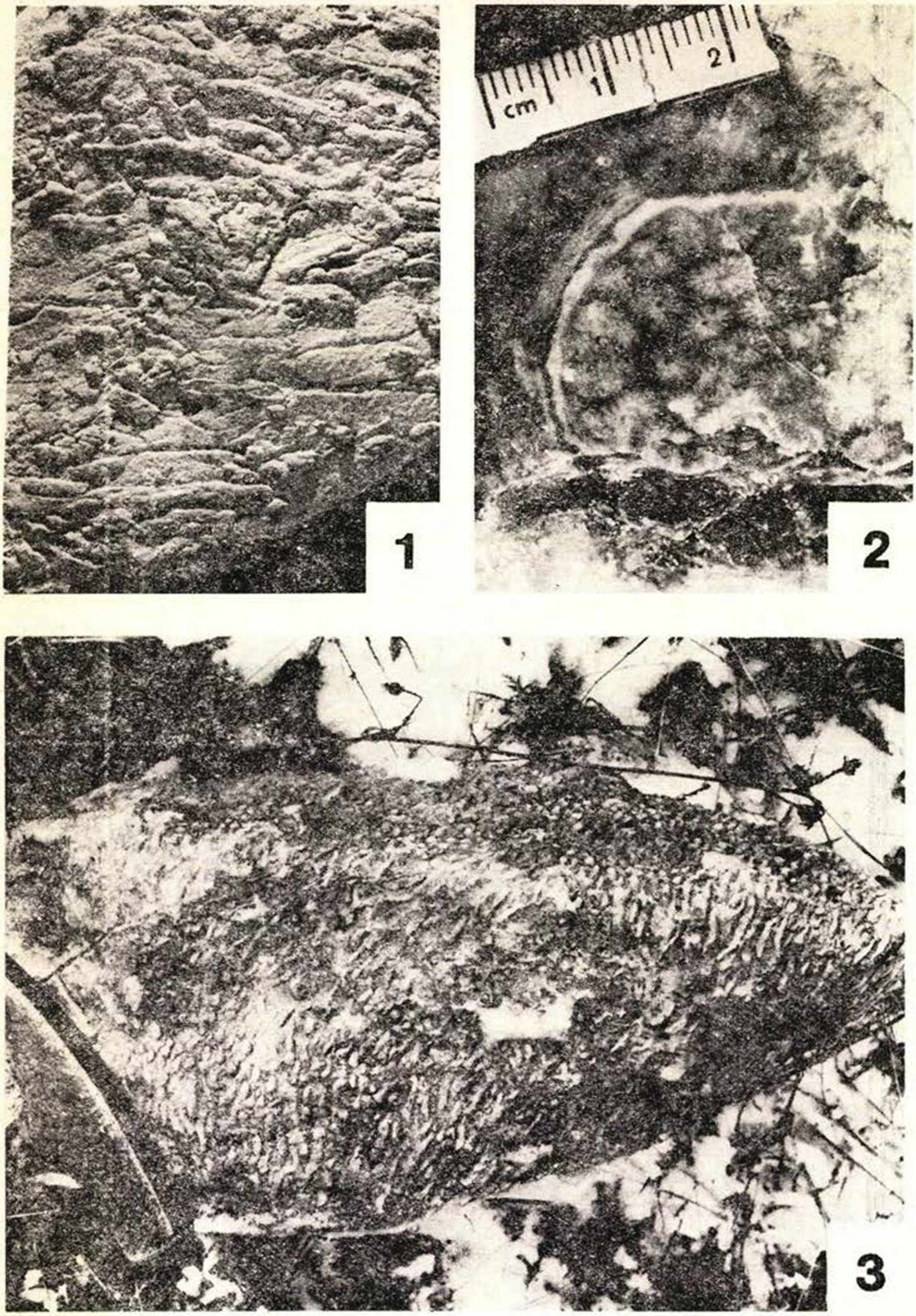
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PLATE XIII.

Fossils of Felsőtárkány quarry
Reef facies

1. and 3. Coral colonies from the E part of Mészvölgy, from the northern part of the one-time quarries, Scree. (Fig. 1: natural size)
2. Algal-coated coral colony from the scree of the quarry.

14

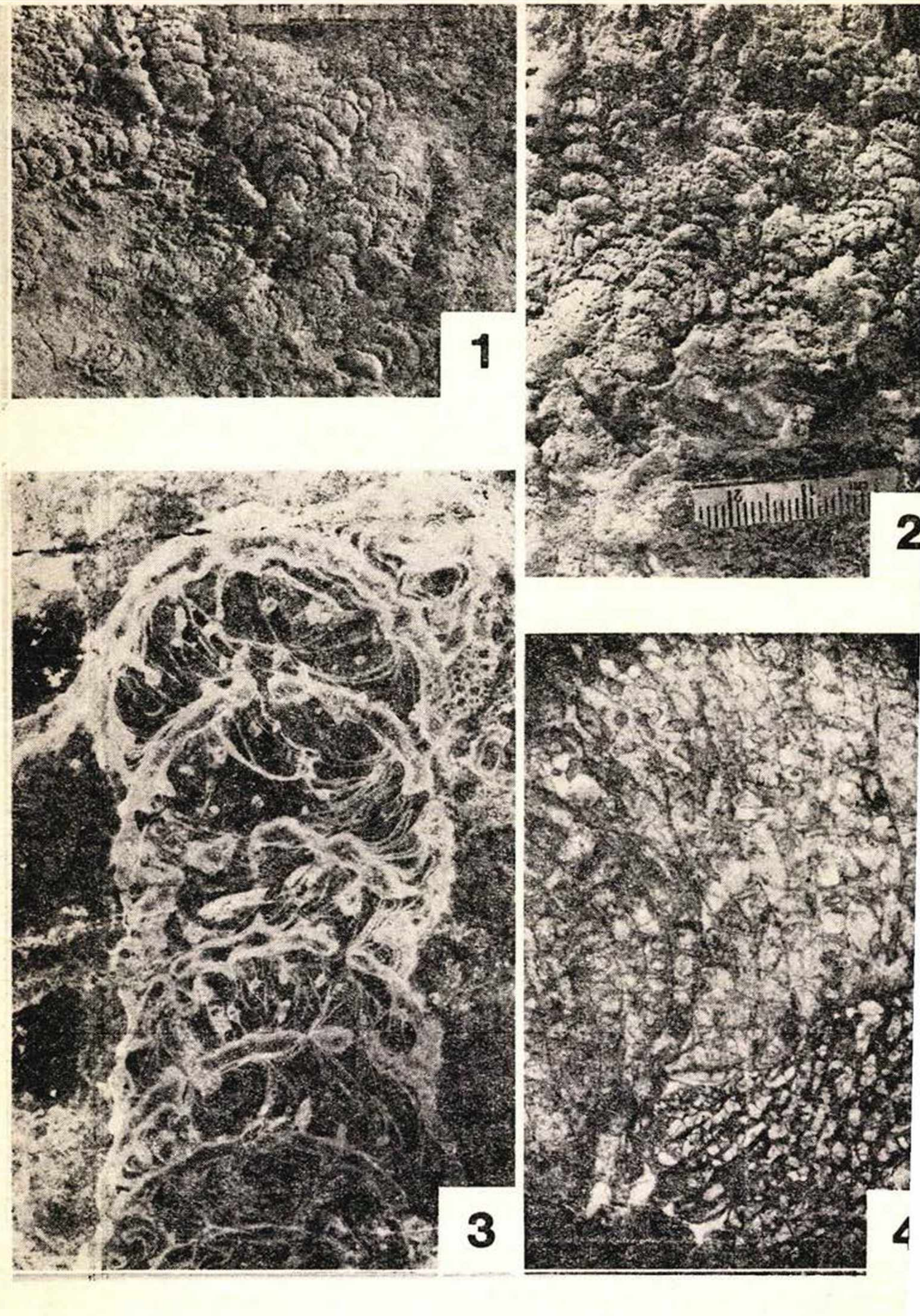
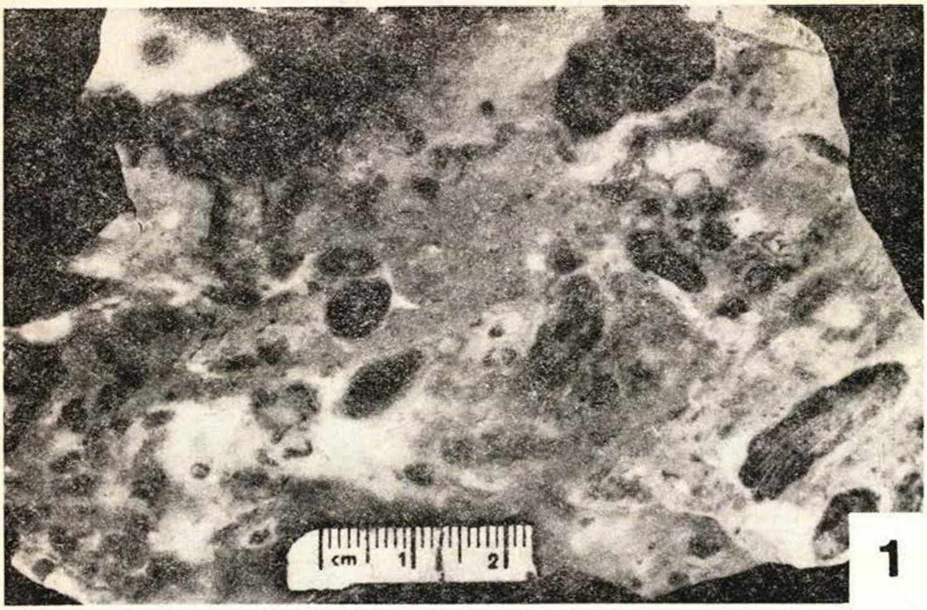


PLATE XIV.

Fossils of Felsőtárkány quarry

Reef facies

1–2. Sphinctozoa colony. E side of Mészvölgy, N end of the one-time quarries, scree.
3. *Cryptocoelia* sp. From quarry scree. Photographic negative. 8x
4. *Cryptocoelia* n. sp.? From quarry scree. 5x


cm 1 2
1


2

PLATE XV.

Felsőtárkány quarry

1. Reef facies with corals.
2. Autochthonous reef facies intercalated with graded, coarse reef detritus.